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Appendix A
Economic Analysis

Economic Analysis	
Project Name:	Sutter Basin Pilot Feasibility Study—Flood Risk Management Project
Project Briefing:	The study area is located in Sutter and Butte Counties, California and is roughly bounded by the Feather River, Sutter Bypass, Wadsworth Canal, Sutter Buttes, and Cherokee Canal. The study area covers approximately 300 square miles and includes the communities of Yuba City, Live Oak, Gridley, Biggs and Sutter with a total population of 80,000.
Study Authority:	The authority for USACE to study Flood Risk Management and related water resources problems in the Sacramento River Basin, including the study area in Sutter and Butte Counties, is provided in the Flood Control Act of 1962 (Public Law 87-874).
Purpose and Scope:	The purpose of this document is to present the economic analysis conducted for the Sutter Basin Pilot Feasibility Study. This includes descriptions of the methodologies, assumptions, data and results of both the without and with project conditions. The document presents findings related to flood risk, potential flood damages, and flood risk management benefits. Additionally, this analysis coincides with the planning modernization paradigm of employing sound qualitative analysis guided by professional judgment rather than heavily based quantitative processes during the planning phase of study process. The economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100) serves as the primary source for evaluation methods. Also, guidance for risk-based analysis was obtained from EM 1110-2-1619 and ER 1105-2-101. Unless otherwise noted, benefits and costs values are expressed in October 2012 prices utilizing the FY12 discount rate of 3.75% and analyzed over a 50-year period of analysis. Economic Modeling was performed using the Corps FRM-PCX certified HEC-FDA (v1.2.5a) model.
Organization of Document:	This document is organized as follows: • Section 1 describes the study area and planning process conducted to date • Section 2 reviews the data used in the analysis and without-project conditions • Section 3 evaluates the final array of alternatives • Section 4 compares the final array of alternatives • Section 5 presents the Other Social Effects analysis • Section 6 discusses the Regional Economic Development impacts • Section 7 summarizes the economic analyses
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Date:	April 2013

1. STUDY BRIEFING

Planning Study. The Sutter Basin Pilot Feasibility Study was selected for inclusion in the National Pilot Program in February 2011. The pilot initiative provides an opportunity to test principles that have been outlined in the U.S. Army Corps of Engineers (USACE) *Recommendations for Transforming the Current Pre-Authorization Study Process* (January 2011), which was drafted by a workgroup of planning and policy experts from USACE and the Officer of the Assistant Secretary of the Army for Civil Works, ASA (CW), referred to as the 17+1 Team. This new process requires heavy involvement as well as input and decisions from the Vertical Team at multiple points throughout the study. The pilot study is divided into four phases, each with a key decision point and associated In-Progress Reviews (IPRs). Table 1 summarizes the four pilot study phases and associated decision points. Based on the pilot program principles, the Sutter Basin Pilot Feasibility Study strategy focuses on utilizing an appropriate level of detail based on the decisions being made at each stage of the study. This strategy includes qualitative analysis that will be increasingly detailed at each Decision Point or IPR and early screening of alternatives with little probability of implementation.

Table 1. Pilot Study Phases and Associated Decision Points

Pilot Study Phase	Decision Point	Date
Scoping	1 – Federal Interest Determination	Aug 2011
Analysis	2 – Tentatively Selected Plan and Draft Report	March 2013
Review	3 – Civil Works Review Board	Summer 2013*
Confirmation	4 – Chief's Report	Fall 2013*

*Dates are pending confirmation from vertical team.

Throughout the planning process, the Sutter Project Delivery Team (PDT) has recorded major milestones in the following documents:

- Appendix I, Measure Screening and Alternative Selection— This Progress Document details the broad array of management measures that were developed based on information from existing reports and studies, as well as public input and professional judgment. This document provides descriptions of the measures evaluated at the Critical Thinking Charette and indicate whether each one was retained or dropped and the reason(s) for screening.
- Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives— This Progress Document is a compilation of a series of memorandums from the following disciplines: economics, civil design, real estate, cost engineering, hydrology, hydraulics, and geotechnical. These documents form the basis for selection of the final array of alternatives.

This documentation is in support of Appendix III, Evaluation and Comparison of the Final Array of Alternatives and Identification of the Tentatively Selected Plan. This document includes the description, evaluation and comparison of the final array of alternatives. For additional detail on the economic methodologies and step taken in the refinement of the draft array of alternatives, please see Progress Document #2, Economic Appendix.

Study Area. The 300 square mile study area is located in Butte and Sutter Counties California. A map showing the location of the study area relative to the watershed is provided as Plate #1. A map of the study area topography is provided in Plate #2, which shows elevation ranges from 110 feet to 30 feet. The study area is encircled by federal project levees along the Sutter Bypass, Feather River, Cherokee

Canal, Wadsworth Canal and the high ground of the Sutter Buttes. The federal levees are features of the Sacramento River Flood Control Project (SRFCP), authorized by Congress in 1917. The SRFCP incorporated features such as levees, weirs, and pumping facilities into a system of leveed river channels and flood bypass channels to provide Flood Risk Management benefits to the Sacramento Valley.

Population estimates from 2010 Census are tabulated by economic impact area in Table 2. A map of the estimated population density throughout the study area is provided in Plate #3.

Table 2. Population

Economic Impact Area	Population
Yuba City Urban	67,370
Biggs Urban	1,760
Gridley Urban	6,380
Live Oak Urban	8,360
Sutter County Rural	6,340
Butte County Rural	4,900
Total	**95,110**

The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage. Flood depths and frequency vary throughout the study area. Probability of flooding within the study area is primarily related to the stage of floodwaters within the river channels and the geotechnical probability of levee failure at flood stage. The Sacramento River Flood Control Project levees were often constructed of poor foundation materials such as river dredge spoils that does not meet current engineering standards. These legacy levees are relied upon today to provide FRM for numerous communities within the Sacramento Valley.

Historical Assessment. In 1955, flood waters from a levee breach encompassed a significant portion of the study area inundating 6,000 homes, drowning 38 people, injuring 3,200 individuals, and requiring 600 people to be rescued by helicopter (Plate #4). From 1950 to 2011, extensive flood fighting has occurred during 19 events, and levee failures adjacent to the Sutter Basin took place in 1986 and 1997. Flooding historically has occurred during the months of December through February with air temperatures of 38 to 55°F and water temperatures of 45 to 55°F; temperatures which significantly increase risk of death by exposure.

Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees within the study area do not meet USACE levee design standards and are at risk of breach failure at stages less than overtopping. This was evidenced by historical boils and heavy seepage at stages less than authorized design flows. Underseepage failures are sudden and unpredictable, resulting in minimal warning time, and ineffectiveness of evacuation plans. Though, almost every location within the study area is afforded some flood risk reduction by these levees, the risk of unexpected levee failure coupled with the consequence of flooding presents a continued threat to public safety, property, and critical infrastructure.

2. REVIEW OF EXISTING CONDITIONS

Floodplain Area and Economic Inventory. An economic inventory was assembled following standard USACE methods. For the study area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sutter and Butte Counties. Field visits were conducted to collect and validate the base inventory data. Parcels with structures were categorized by land use and grouped into residential, commercial, industrial or public categories. The value of damageable structures was estimated based on depreciated replacement values. The total value of damageable property (structures and contents) within the Sutter Basin study area is estimated at $6.9 billion (Table 3). Table 4 displays the structural inventory by land use category.

Table 3. Value of Damageable Property
October 2012 Prices (Values in 1,000's)

Economic Impact Area	Structures and Contents				
	Commercial	Industrial	Public	Residential	Total
Biggs	6,600	2,400	0	74,600	**83,600**
Gridley	72,200	51,900	3,500	286,800	**414,300**
Live Oak	25,600	3,700	42,000	319,900	**391,200**
Yuba City	1,054,800	417,800	334,400	3,593,600	**5,400,700**
Rural Butte	3,900	45,700	0	200,300	**249,800**
Rural Sutter	9,000	39,600	18,500	275,000	**342,200**
Total	**1,172,200**	**561,000**	**398,500**	**4,750,100**	**6,881,900**

Table 4. Structural Inventory –Existing Conditions
Number of Structures within 0.2% (1/500yr) Annual Chance Floodplain

Economic Impact Area	Commercial	Industrial	Public	Residential	TOTAL
Biggs	18	1	0	586	**605**
Gridley	81	7	4	1,931	**2,023**
Live Oak	51	5	23	2,088	**2,167**
Yuba City	872	210	122	18,760	**19,964**
Rural Butte	10	16	0	1,242	**1,268**
Rural Sutter	10	29	8	1,162	**1,209**
Total	**1,042**	**268**	**157**	**25,769**	**27,236**

HEC-FDA Modeling Efforts. For the economic analysis, the existing levees were separated into thirteen levee reaches and a representative breach location was chosen for each reach. When the study area becomes inundated, the floodwaters flow from north to south and then pool in the southern portion of the study area to twenty feet or more. Therefore, a levee breach at the northern section of the Feather River would result in a larger inundation area than a breach at the southern portion, but does not necessarily mean that a northern breach has the highest risk (probability and consequence). Because the levees around the Sutter study area have distinct deficiencies, each has a different probability of failure in any

given flood event. The probability of flooding from each source is based on the hydrologic frequency, stage-discharge relationship and geotechnical performance. These parameters serve as inputs into the Corps FRM-PCX certified HEC-FDA model (v1.2.5a).

Without-Project Damages. The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software. This program stores the engineering probability data (hydrologic, hydraulic, and geotechnical) and the economic consequence data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area. By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits. The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

The HEC-FDA without project conditions model results (expected annual damages) for structures, contents, automobiles, and agriculture are shown, by economic impact area (EIA) in Table 5. The total study area without project damages are estimated to be $114 million.

Table 5. Expected Annual Damages—Without Project Condition
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Economic Impact Area	Damage Category						
	Agriculture	Autos	Commercial	Industrial	Public	Residential	Total
Biggs	4	88	80	30	0	488	**689**
Gridley	5	176	998	296	48	973	**2,495**
Live Oak	9	240	322	52	464	1,435	**2,523**
Yuba City	246	4,175	15,477	6,342	4,207	26,031	**56,477**
Rural Butte	1,875	134	51	260	0	759	**3,079**
Rural Sutter	16,227	1,928	1,110	5,660	3,383	18,476	**46,783**
Total	**18,366**	**6,739**	**18,039**	**12,639**	**8,101**	**48,162**	**112,046**

Without Project Performance. In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and assurance by event.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.

- Assurance is the probability that a target stage will not be exceeded during the occurrence of a specified flood.

The worst project performance statistics may not necessarily be associated with the breach location producing the largest economic damages. For example, an impact area may be subject to flooding from two different rivers. River A might have a higher likelihood of flooding than River B but River B's associated floodplain (consequence) may be larger and cause more damages. If that is the case, then project performance (likelihood of flooding) is not the primary dictator in consequence. Nevertheless, if a proposed project alleviates River B's floodplain, the project performance is still limited by River A's performance. For the Yuba City economic impact area, performance is dictated by an index point along the Sutter Bypass. However, the associated floodplain does not impact Yuba City until the 0.2% ACE whereas a break along the Feather River poses imminent damages due to its associated consequence (floodplain) even though it statistically has a higher performance when compared to the Sutter Bypass. Project performance statistics for each area under without project conditions is displayed in Table 6.

Table 6. Project Performance by Economic Impact Area—Without Project Condition

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Yuba City	F5.0R	0.04	0.04	33%	70%	86%	85%	67%	60%	22%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	100%	100%	33%	30%	22%	6%

Agricultural Damages. ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. Primary damages in this evaluation focus on the crop damage, loss of stored crops, and loss of farm equipment. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies. Based on empirical analyses conducted for past Corps projects, subject matter expertise from the agricultural economist and professional judgment, the project delivery team expects agricultural damages to total 10-15% of total project damages; amounts which are not expected to drive plan selection. A simplified approach was developed for this study based on stage-damage curves for land use types within the study area and simplifying calculations by utilizing 1,000 ft by 1,000 ft hydraulic model grid elements. For detailed information regarding data collection, assumptions, and methodology see the Memorandum for File titled "Agricultural Damages for Final Alternative Comparison" dated 22 February 2013 (Enclosure 1).

3. ALTERNATIVE EVALUATION

Plan Formulation and Description of Alternatives. The plan formulation process develops and evaluates alternative plans to address the needs and desires of society as expressed in specific planning objectives. Accordingly, the tentatively selected plan best satisfies the objectives as well as the Federal interests, which are consistent with the Federal Water Resources Council's Principles and Guidance (P&G) and the Planning guidance Notebook (ER-1105-2-100). What follows is a brief timeline of the planning process leading up to the final array of alternatives. More detail can be found in Progress Document #1.

(1) Management Measures (Critical Thinking Charette): A broad array of management measures was developed based on information from existing reports and studies, as well as public input and professional judgment. Following the initial screening of measures, the team identified four themes (strategies) for plan formulation (1- Consequence Management Focused on Public Safety, 2-Urban FRM, 3-Maximize Existing System with FRM Focus, and 4-Ecosystem Restoration Focus). These themes were used to establish a preliminary array of conceptual alternatives by grouping measures according to the primary focus of each theme.

(2) Preliminary Array of Alternative: Each alternative was further developed and quantities, costs and economic benefits were estimated at a reconnaissance level. The use of these results was solely to screen out those preliminary alternatives that did not appear economically justified even in the most favorable conditions.

(3) Refinement of Draft Array of Alternatives (Value Engineering Study): The remaining alternatives were furthered refined. This resulted in combining and eliminating some of the alternatives as well as refining and optimizing those that were retained by adding or removing measures in order to ensure a robust array of draft alternatives. The draft array of alternatives were then evaluated in further detail, and screened to a final array of alternatives. See Economic documentation in support of Appendix II, Draft Alternative Evaluation and Selection of Final Alternatives, for more detail.

(4) Final Array of Alternatives: The final array of alternatives carried forward for final comparison include:

- Alternative SB-1: No Action
- Alternative SB-7: Fix-in-place the Feather River, Sunset Weir to Laurel Avenue
- Alternative SB-8: Fix-in-place the Feather River, Thermalito to Laurel Avenue

With-Project Modeling Results. Benefits were determined by incorporating increments of levee fixes into the HEC-FDA model that represent various with-project improvements. Flood risk management benefits (Table 8) equal the difference between the without project damages (Table 5) and the with-project residual damages (Table 7).

Table 7. Expected Annual Damages—Alternative Conditions
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	689	2,495	2,523	56,477	3,079	46,783	112,046
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	689	2,495	2,523	8,289	3,079	31,071	48,146
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	263	348	396	8,281	1,467	30,721	41,476

Table 8. Annual Benefits—Alternative Conditions
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Economic Impact Area						Total
	Biggs	Gridley	Live Oak	Yuba City	Rural Butte	Rural Sutter	
SB-1: No Action	-	-	-	-	-	-	-
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	-	-	-	48,188	0	15,712	63,900
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	426	2,147	2,127	48,196	1,612	16,062	70,570

Probability Distribution of Damages Reduced. In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 9 shows the benefits for each alternative for a probability distribution and expected value. The damage reduced column represents the expected benefits for each alternative, while the probability damage reduced indicate the confidence of benefits exceeding the indicated amount. For example, Alternative SB-7 has expected benefits of $57 million at the 50% confidence interval, and 75% confidence that benefits will be equal to or greater than $37 million. The range in probability distribution of damages reduced is indicative of the uncertainty in the benefits estimates, which incorporates all the uncertainties in hydrology, hydraulics, geotechnical and economics in the HEC-FDA model. The uncertainty in damages reduced is a critical component when selecting an optimal plan during the plan formulation process. Professional judgment guides the determination of an alternative meeting a reasonable level of confidence regarding positive net benefits.

Table 9a. Probability Distribution of Damages Reduced—Study Area
October 2012 Prices (Values in $1,000s), 3.75 Discount Rate

Alternative	Annual Damages			Probability Damage Reduced		
	Without Project	With Project	Damage Reduced	75%	50%	25%
SB-1: No Action	112,046	112,046	0	0	0	0
SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	112,046	48,146	63,900	35,742	52,323	87,895
SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue	112,046	41,476	70,570	38,445	58,915	97,166

Table 9b. Project Performance by Economic Impact Area—Alternative SB-7

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Gridley	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Live Oak	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Yuba City	F3.0R	0.002	0.003	3%	8%	13%	99%	99%	97%	48%
Rural Butte	F9.0R	0.07	0.08	55%	91%	98%	82%	61%	58%	32%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	6%

Table 9b. Project Performance by Economic Impact Area—Alternative SB-8

Economic Impact Area	Breach Location	Annual Exceedance Probability		Long Term Risk			Assurance by Event			
		Median	Expected	10-yr period	30-yr period	50-yr period	10%	2%	1%	0.20%
Biggs	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Gridley	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Live Oak	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Yuba City	F3.0R	0.002	0.003	3%	8%	13%	99%	99%	97%	48%
Rural Butte	F9.0R	0.002	0.002	2%	7%	11%	99%	99%	97%	64%
Rural Sutter	S4.0L	0.45	0.52	99%	99%	99%	33%	30%	22%	6%

4. ALTERNATIVE COMPARISON

Net Benefit Analysis. Economic feasibility and project efficiency are determined through a benefit-cost analysis. For a project to be feasible, benefits must exceed costs and the most efficient alternative is one that maximizes net benefits (annual benefits minus annual costs). The identification of such alternative is referred to the National Economic Development Plan (NED). Table 10 summarizes the net benefit analysis of the final array of alternatives using probability reduced damages at varying confidence intervals in terms of benefits and costs (25%, 50% and 75%), while Table 11 shows the net benefit analysis using the mean computed benefits and cost at an 80% confidence level[1] per standard USACE practice.

Table 10. Net Benefits[2] (Varying Confidence Intervals)—Final Array of Alternatives October 2012 Prices (Values in $Millions), 3.75 Discount Rate

Category	Alternative						
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue			SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue		
		Low	Mid	High	Low	Mid	High
Total First Costs		392	410	430	676	708	742
Less Cultural Resources (-)		-3	-3	-3	-3	-3	-3
Interest During Construction (+)		25	33	42	61	81	102
Subtotal		***414***	***440***	***469***	***734***	***786***	***841***
Interest and Amortization		18	20	21	33	35	38
OMRR&R			0.28			0.45	
Annual Cost		18	20	21	33	36	38
Annual Benefits		36	52	88	38	59	97
Net Benefits		**23**	**39**	**58**	**11**	**30**	**51**
Benefit to Cost Ratio		**2.1**	**3.0**	**4.0**	**1.3**	**1.8**	**2.5**

[1] Standard practice in Corps Feasibility Studies.

[2] Net Benefits and Benefit to Cost Ratios are a result of Monte Carlo simulations using triangular distributions of annual benefit and annual costs confidence intervals as inputs.

Table 11. Net Benefits (Mean, Standard Corps Practice)—Final Array of Alternatives October 2012 Prices (Values in $Millions), 3.75 Discount Rate

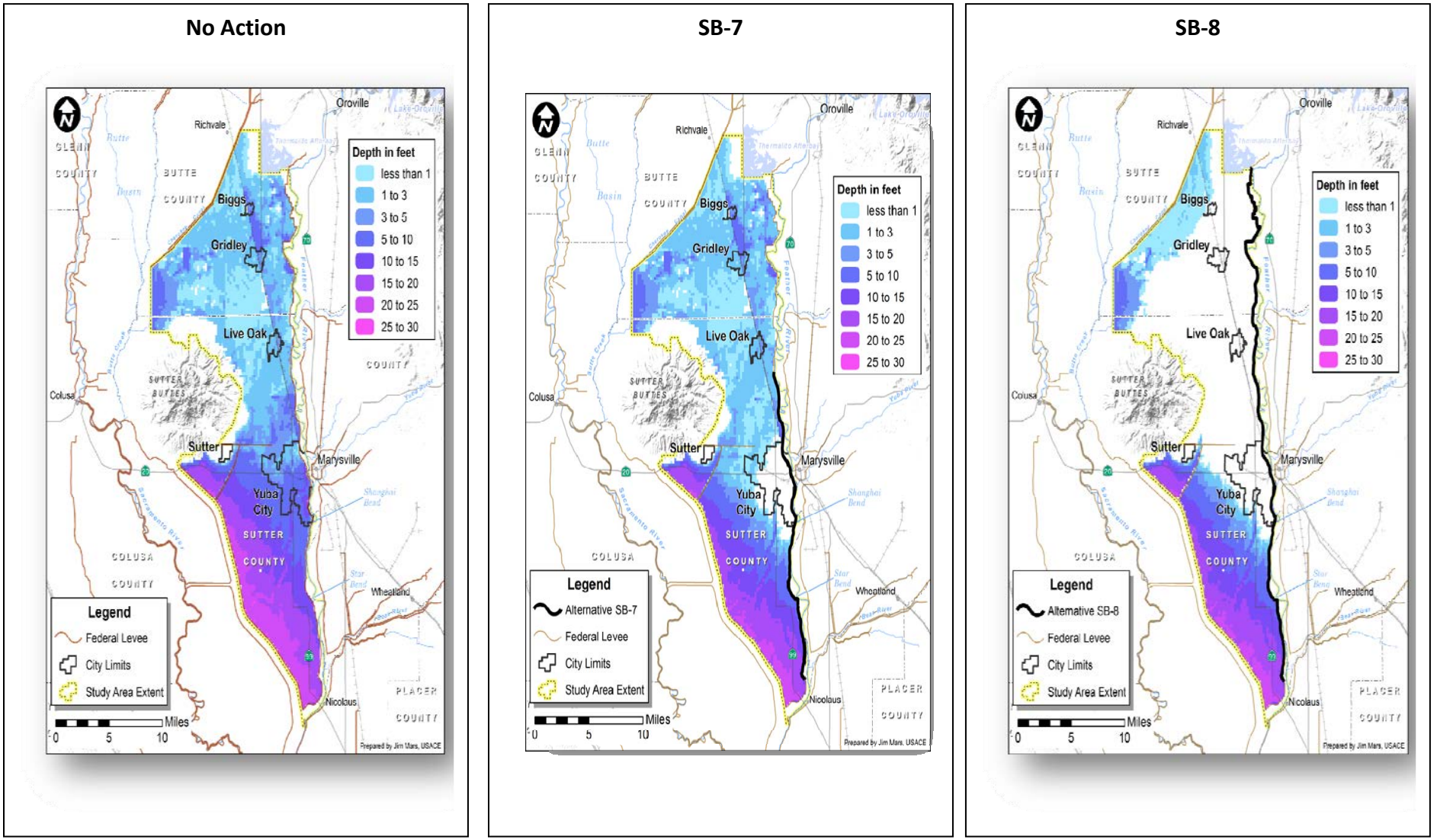
Category	Alternative		
	SB-1: No Action	SB-7: Fix-in-place Feather River, Sunset Weir to Laurel Avenue	SB-8: Fix-in-place Feather River, Thermalito to Laurel Avenue
Total First Costs		432	748
Less Cultural Resources (-)		-3	-3
Interest During Construction (+)		44	107
Subtotal		***473***	***853***
Interest and Amortization		21	38
OMRR&R		0.28	0.45
Annual Cost		21	38
Annual Benefits		64	71
Net Benefits		**43**	**33**
Benefit to Cost Ratio		**3.0**	**1.9**

Residual Floodplains: Residual 1% ACE floodplains[3] for the final array of alternatives are shown in figures below. SB-7 reduces adverse flooding effects but benefits are primarily centered on Yuba City. The alternative features do not address the significant flooding risk in the communities of Biggs, Gridley, and Live Oak. SB-8 reduces the residual risk for the northern communities.

Residual Population at Risk (PAR): PAR within the 1% ACE floodplain for the No Action Alternative is 94,600. SB-7 reduces the 1% floodplain PAR to 38,200, while SB-8 reduces PAR to approximately 6,600.

[3] 1% floodplains are based on the inundation from any levee having less than 95% assurance. The assurance estimate was based on geotechnical, hydraulic, and hydrologic uncertainty.

Figure 1: 1% ACE Residual Floodplains for the Final Array



5. OTHER SOCIAL EFFECTS

Purpose and Methodology. This portion of the economic analysis documents the results of the Other Social Effects (OSE) account analysis associated with the Sutter Basin Pilot Feasibility Study. The analysis is intended to provide a portrait of the social landscape of the study area and offer a glimpse as to the vulnerability of the populations that call Sutter Basin their home.

A concern for social effects associated with water resources development and management has long been part of federal water resources planning guidance, appearing as the Social Well-being Account in 1972 *Principles and Standards*, and later as the OSE account in the *Principles and Guidance* (P&G) adopted in 1983 and in the Corps' ER 1105-2-100. However, since the adoption of the P&G there has been a tendency to discount the role and importance of OSE factors in water resources planning. Now, new guidance is being promulgated and implemented—principally EC 1105-2-409 *Planning in Collaborative Environment*—is placing much greater emphasis on the importance of including a broad range of considerations in planning. In addition to NED factors, other considerations, including social factors addressed in the OSE account, are to be used to develop appropriate water resources solutions.

Essentially, the OSE account serves to answer the following question:

> *How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?*

Metrics:

- Social Connectedness will be measured using Gender, Race & Ethnicity, Age, Rural/Urban Communities, Rentals vs. Homeownership and Occupation.
- Community Social Capital will be measured using Education, Family Structure, Rural vs. Urban Communities and Population Growth.
- Community Resilience will be measured using Income, Political Power, Prestige, Employment Loss, Residential Property, Infrastructure/Lifetime, Family Structure and Medical Services.

This assessment is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The *Planning Guidance Notebook* (ER 1105-2-100) serves as the primary source for evaluation methods of flood risk management studies and was used as a reference for this analysis. Additionally, the Institution for Water Resources *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4) served instrumental in conducting the analysis.

This report analyzes the social effects related to the without and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the basis for the analysis of impact.

Historic Digest. The topography of the Sutter Basin is composed primarily of the gentle flatlands of the Sacramento Valley. Prior to the settlement of European populations, the basin was dominated by immense wetlands and riparian forest. The historic habitats of Sutter Basin supported large populations of waterfowl and other wildlife. In the 1830s, European settlers started to cultivate the basing for

agricultural use. Other practices included livestock grazing and controlled burns. The late 1800s brought gold miners during the Gold Rush and later cattle drivers that stayed to continue to use the rich soil for agriculture production. This resulted in lower areas and interior valleys being sparsely inhabited by ranchers and farmers. By the 1930s, the majority of the basin was cultivated for agricultural production and cattle grazing. Currently, the basin is a major agricultural center in northern California. Sutter basin is composed of two counties, Sutter and Butte. Both of which are primarily agricultural communities. The *2001 Census of Agriculture* classifies 88% of Sutter County's acreage of being in farms. The five leading crops based are rice, peaches, walnuts, dried plums, and tomatoes. Within the Sutter Basin study area boundary, Sutter County includes two cities (Yuba City and Live Oak), and Butte County includes another two cities (Biggs and Gridley).

Social Profile. A first key step in helping the decision-makers gain a better understanding of the social landscape—e.g., identifying who lives in the study area, who has a stake in the problem or issue and why it is important to them. This fundamental step entails performing a profile of the area in terms of basic social statistics, and to make such presentation of information meaningful by providing useful comparisons and rankings. The preparation of the social profile is not the OSE analysis. Social profiling provides the basic level of understanding about the social conditions, but more in-depth analysis is required to target areas of special concern or relevance to the specifics of the water resources issues. The basic social statistics discussed below are indicators used to portray basic information about the social life and the processes of the area under study. The development of these basic social characteristics (Table 12) present a portrait of the study area.

The 300 square mile study area is home to over 95,110 people. Approximately 88% of the total population abides in one of four incorporated cities. Yuba City makes up the majority of the population with 64,900 individuals. The communities of Live Oak, Gridley and Biggs have 8,400, 6,600, and 1,700 persons, respectively. The remainder of the population of 11,240 individuals reside in the surrounding rural areas of Sutter and Butte Counties. The study has seen a significant increase in population over the last decade. The growth has been primarily centered in Yuba City, which saw its population grow from 36,760 people in 2000 to 60,510 in 2006, a 65% increase.

The median age of the study area is consistent with State and national averages; as is the population over 65. However, the population under 18 years of age is higher in the study are (>28%) compared to State (25%) and national (24%) averages. Education statistics indicate lower levels of attainment. The percent of individuals over 25 with a high school degree (or equivalent) and percent of college graduates are lower than State and national averages.

Variances in race and ethnicity in communities may impose language and cultural barriers that affect ability to cope with natural hazards. The Hispanic presence is evident given they make up at least 28% of the population in each community. Live Oak's population is composed of 48.8% of individuals of Hispanic origin, which is significantly higher than the State average of 37.6% and greatly exceeds the national average of 16.3%.

Median household income for the study area ranges from $36,563 (Gridley) to $48,830 (Yuba City). Both of which are below State ($61,632) and national (52,762) averages. The persons living at or below the poverty level in the study area are 22.7%, 21.4% and 15% for Biggs, Gridley and Yuba City, respectively. All of which are larger than the State (14.4%) and national (14.3%) averages.

The total labor force in the study area is estimated at 40,000, with an unemployment rate of 14.7%, 8.4%, and 9.3% in Biggs, Gridley and Yuba City, respectively. Total private wage or salary workers estimated to be 75% (Biggs), 65% (Gridley) and 69% (Yuba City) with 17% (Biggs), 25% (Gridley) and 20% (Yuba City) of the labor force rated as government workers. Approximately, 7% (Biggs), 11% (Gridley) and 11% (Yuba City) of the labor force was considered to be self-employed, not incorporated. The average wage per job so the study area is between $22,300 to $28,100.

Table 12. Basic Social Characteristics—Sutter Basin Study Area
2010 Census Demographic Data

Basic Social Statistic	Study Area Community				California	National
	Biggs	Gridley	Live Oak	Yuba City		
Population						
Current Population (2010)	1,760	6,380	8,360	67,370	37,254,000	308,746,000
Age						
Median Age	35.1	33.1	31.7	33	35.2	37.2
% 65 and above	10.9%	14.1%	10.7%	11.7%	11.4%	13.0%
% under 18	28.1%	28.7%	30.6%	28.2%	25.0%	24.0%
Race and Ethnicity						
Asian	0.5%	3.7%	11.4%	17.0%	12.8%	4.7%
Black	0.4%	0.5%	1.4%	2.2%	5.8%	12.2%
Hispanic	34.0%	45.6%	48.8%	28.4%	37.6%	16.3%
White	60.5%	46.7%	35.0%	47.4%	40.1%	63.7%
Other	4.6%	3.5%	3.4%	5.0%	3.7%	3.1%
Education						
% HS Graduates	75.1%	64.6%	-	77.6%	80.8%	85.4%
% College Graduates	9.3%	10.1%	-	19.2%	30.2%	28.2%
Income and Poverty Status						
% Unemployed	14.7%	8.4%	-	9.3%	6.5%	5.6%
Median Household Income	$44,485	$36,563	-	$48,830	$61,632	$52,762
Persons below Poverty (%)	22.7%	21.4%	-	15.0%	14.4%	14.3%
Housing						
Homeownership Rate	69.4%	57.8%	65.9%	56.9%	55.9%	65.1%
% of Mobile Homes	2.7%	3.6%	-	4.4%	3.9%	6.6%
Quality of Life						
Average Household Size	3.37	3.63	3.88	3.49	3.45	2.58
Language Other than English Spoken at Home	32.6%	43.7%	-	40.1%	43.2%	20.3%
Mean travel time to work (minutes)	26.4	21	-	28	27	25.4

Social Effects Assessment.

Social Vulnerability and Resiliency: Social vulnerability is a term described by the sensitivity of a population to natural hazards, where as resiliency refers to the population's ability to respond to and recover from the impacts of such hazard. The characteristics that are recognized as having an influence on social vulnerability generally include age, gender, race and socioeconomic status. Other characteristics include population segments with special needs or those that lack the normal social safety nets necessary in disaster recovery, such as the physically or mentally challenged, non-English speaking immigrants, transients and seasonal tourists. The quality of human settlements (housing type and construction, infrastructure and lifelines) and the built environment are also important in understanding social vulnerability, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 13 provides discussion of factors that may dictate vulnerability and ability to cope with natural hazards, along with an assessment as it relates to the Sutter Basin study area.

Table 13. Social Vulnerability and Resiliency Indicators
Assessment of the Sutter Basin Study Area

Indicator	Discussion	Assessment
Income, political power, and prestige	This measure focuses on ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	As a measure, median household income of the study area is less than the State and national average. The communities may be at a disadvantage in recovery efforts.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages and family care responsibilities.	Although data is not specifically available concerning the wage rate of male versus female for the study area, it is recognized that a smaller percent of women are employed in the labor force in the study area than in the larger metropolitan city of Sacramento. However, the percent of variation of this factor is quite small.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding and residential locations in high hazard areas.	It is recognized that the study areas has a significant Hispanic population, which may pose a risk to the resiliency of the community. Of particular note is the fact that between 33-43% of the population speak a language other than English at home.
Age	Extremes of the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected, elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those over 65 years of age are estimated at 11-14%, which is similar to State and national averages. Those under 5 years of age are estimated at around 8%, which is slightly above State and national averages.
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster.	The current unemployment rate of the study area is higher than the State, which indicates that there may be financial issues in dealing with re-establishing housing.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and more dependent on locally based resource extraction economies (farming and fishing). High-density areas (urban)	Because 12% of the population reside in the rural areas of the study area, there may be concern in their ability to recover from

	complicate evacuation from harm's way.	natural hazards.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	Percentage of mobile homes are similar to State averages, both of which are less than the national average.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	The smaller communities of Biggs, Gridley, and Live Oak are at a greater risk of coping with a natural hazard given their lack of financial resources when compared to the larger urban community of Yuba City.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging become uninhabitable or too costly to afford.	Housing rentals range between 30-43% of Sutter Basin's households. The high rental population highlights indications of community cohesion issues. Research indicates that renters do not have the same community pride as owners thereby having more barriers to direct community involvement in redeveloping the community after a natural hazard.
Occupation	Some occupations, especially those involving resource extraction, may be severely impacted by a hazard event. Self-employed fisherman suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (housekeeping, childcare, and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	Because the study area's industry is primarily driven by agricultural production, many workers may have a difficult time coping with natural hazards.
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience torecover from hazards.	The literature indicates that families having over 4 or more persons have more financial difficulty than those of lesser numbers. Accordingly, community planners need to be aware of pending issues.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	With between 23-35% of Sutter Basin's residents having less than high school education there may be constraints in the ability of those residents to adequately deal with local, state, and federal information requirements surrounding recovery efforts.
Population Growth	Counties experiencing rapid growth lack available quality housing and the social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Sutter Basin has grown significantly in the past 10 years. A rapid growth rate in population is highly correlated with low community cohesion. The sense of belonging, cooperation, and strong sense of community pride are dynamic factors, which assist in the restoration of the community after a catastrophic event. Due to rapid growth in Yuba City, community bonds and sense of owning community issues may not be as strong as other more slowly growing cities like Biggs, Gridley, and Live Oak.

Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	Sutter Basin has many medical facilities available to its general population. This indicates very high medical assistance should natural hazard occur. Additionally, the nearby city of Sacramento is equipped to provide some medical assistance to the residents of Sutter Basin.

Environmental Justice: Executive Order 12898 concerning environmental justice provides direction on the analysis of social and economic effects that would be applicable to proposed flood risk management projects. Signed by President Clinton in 1994, EO 12898 (Federal Actions to Address Environmental Justice in Minority and Low-Income Populations) requires that environmental analyses of proposed Federal actions address any disproportionately high and adverse human health or environmental effects on minority and low-income communities. Additionally, EO 13045 (Protection of Children from Environmental Health Risks and Safety Risks) requires Federal agencies to identify, assess, and address disproportionate environmental health and safety risks to children from Federal actions.

(1st Step) According to the guidelines established to assist the Federal and State agencies in examining potential for environmental justice impacts, the first step in conducting an environmental justice analysis is to define minority and low income populations. Based on these guidelines, a minority and low-income population is present in a project study area if:

- The minority population of the affected area exceeds 50 percent or the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- The project study area is composed of 50 percent or more people living below the poverty threshold, as defined by the U.S. Census Bureau, or it is significantly greater than the poverty percentage of the general population or other appropriate unit of geographic analysis.

(2nd Step) The second step of an environmental justice analysis requires a finding of a high and adverse impact. The executive orders address the impacts on the demographic, economic, and social factors that could measurably alter the economic condition (i.e., the availability of employment), the accessibility of goods, infrastructure and services, and the quality of life in the area of influence. These types of impacts would be significant to the affected population. More specifically, a proposed project alternative would have a significant socioeconomic impact if it were to result in any of the following effects:

- Long-term increase in population that could not be accommodated by regional infrastructure (i.e., housing, utilities, roads, hospitals and schools) or services (such as police and emergency services)
- A reduction in the availability of affordable housing, which could occur either through a large increase in housing prices or a large decline in the supply of affordable housing
- Long-term displacement of population that could not be accommodated within the region

- Long-term displacement or disruption of local businesses that could not be accommodated within the region
- A loss in community facilities, events, populations, or major industry that would result in an overall loss in community cohesion
- Disruption of emergency services or creation of a public health risk that could not be avoided by the public, especially if it would particularly affect the health and safety of children

(3rd Step) A proposed project alternative would have an environmental justice impact if it were to cause impacts that are disproportionately high and adverse, either directly, indirectly or cumulatively. To make a finding that disproportionately high and adverse effects would likely fall on a minority or low-income population, three conditions must be met simultaneously:

- There must be a minority or low-income population in the impact zone
- A high and adverse impact must exist
- The impact must be disproportionately high and adverse on the minority or low-income population

Review of real estate records and discussion with USACE Sacramento District PDT disclosed that the construction of Alternative SB-7 and SB-8 have no major direct impact to residents in the immediate area. Implementing the proposed alternative would have a beneficial impact on the regional economy due to increased expenditures in the regional economy during the construction period. However, increased construction-related traffic, delays, and detours as well as an increased population due to the presence of a construction workforce can result in increased social tension during the construction period. Nevertheless, the conclusion based on the environmental justice criteria, is that there is no highlt adverse impact due to construction of either alternative project.

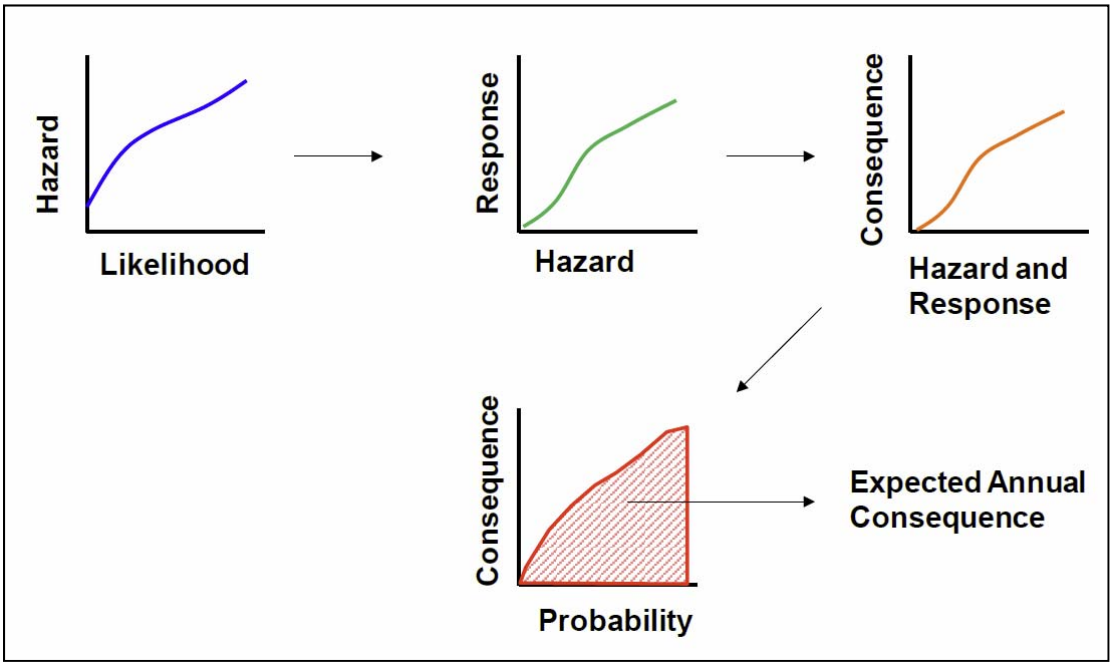
Life Safety Evaluation. Methods to calculate economic losses from natural hazards are fundamental to the planning process. However, such losses only capture part of the impact of natural hazards, and alternatives based only on reducing such damages miss a wide range of other important effects. A critical missing element from the current flood damage assessment approach is estimating the potential for loss of life and injury associated with flood events and flood damage reduction interventions. Current methodology has reached high level of sophistication but requires significant technical resources. However, the planning modernization paradigm calls for approaches that employ sound qualitative analysis guided by professional judgment rather than heavily focused high resource consuming quantitative processes.

Economists conducting the Sutter Basin Pilot Feasibility Study decided to make use of the Levee Screening Tool (LST) to facilitate preliminary assessment of the general condition and associated risks of levees in support of loss of life estimation. The LST provides an initial quantitative risk estimate to assist local, state, and Federal stakeholders in identification and prioritization of funding needs for levees of concern. All inputs for the LST will be estimated from readily available data. Estimates of the flood loading are made from information such as design documents, gage records, flood insurance studies, or project specific studies. An assessment of performance is based on results of the routine levee inspection and an engineering assessment of performance related items from the levee inspection checklist based on

a review of design documents and other relevant engineering data. Life safety consequences within the study area are estimated from readily available data.

The risk associated with levee segments and systems can be characterized by considering the magnitude and likelihood of a hazard (i.e. loading), the conditional response of the levee given the loading (i.e. performance), and the potential consequences that result from the combination of loading and response. Various loading scenarios may be possible as a result of the types of loading (e.g. flood), operational performance (e.g. gate closure), human intervention (e.g. sandbagging during a flood fight), or outcomes external to the levee system (e.g. upstream reservoir operations or failure of a nearby levee system). Performance of the levee can be described by one of the following inundation scenarios: 1) Breach prior to overtopping, 2) Overtopping with breach, 3) Overtopping without breach, and 4) Component malfunction. Multiple performance modes (e.g. seepage and piping, overtopping, floodwall stability) can influence performance of the levee system and each performance mode can have different consequences depending on the location and severity of a levee breach. Consequences can also be influenced by various factors such as the effectiveness of warnings and evacuations and the depth, velocity, and rate of rise of flooding. The three primary inputs (load, performance, consequences) can be combined using probabilistic methods to obtain a risk estimate represented as a probability distribution of potential consequences. The expected value of risk (i.e. average annual) is often computed from this distribution and used as a point estimate of the risk. Point estimate results are commonly displayed on an f,N chart with the vertical axis representing the annual likelihood of inundation and the horizontal axis representing the average magnitude of consequences. A conceptual representation of the risk framework is provided in Figure 1.

Figure 2. Conceptual Risk Framework



The consequence portion of the LST includes computation that allow for an estimate of loss of life caused by inundation due to breach or overtopping of a levee. Readily available data and information are used

along with limited analysis to assess the potential consequences related to a breach prior to overtopping of a levee segment. The consequences section of the LST is subdivided into the categories of general information, evacuation effectiveness, fatality rate computation, and critical infrastructure. For additional information on methodology please see the *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1).

The computed fatalities under a breach scenario for the without-project condition are estimated to be 388 and 489 for day and night settings, respectively. Table 14 indicates the results of the application of the LST to the estimated population under each alternative scenario. To the approximately 38,300 people at risk under Alternative SB-7, the potential loss of life estimate is 157 (day) and 197 (night) lost lives. And to approximately 6,640 people at risk under Alternative SB-8, the potential loss of life estimate is 27 (day) and 34 (night).

Table 14. Loss of Life Estimate

Community	Alternative					
	SB-1		SB-7		SB-8	
	Day	Night	Day	Night	Day	Night
Biggs	6	8	6	8	0	0
Gridley	26	33	26	33	0	0
Live Oak	34	43	34	43	0	0
Yuba City	276	348	47	59	14	18
Rural Butte	20	25	20	25	0	0
Rural Sutter	26	32	24	30	13	16
Total	**388**	**489**	**157**	**197**	**27**	**34**

In addition to loss of life evaluation, other metrics were developed to assess the vulnerability of individuals living in the study area. Table 15 describes the metrics used to further evaluate life safety and Table 16 shows their results by alternative.

Table 15. Description of Metrics

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE Floodplain based on the 2010 census blocks.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance.
Evacuation Routes (# of Routes)	Assesses the vulnerability of populations with regards to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 16. Summary of Life Safety Metrics

Evaluation Metric	Alternative		
	SB-1	SB-7	SB-8
Population at Risk (People)	94,600	38,200	6,600
Critical Infrastructure (Facilities)	28	11	1
Evacuation Routes (# of Routes)	0	1	5
Wise Use of Floodplains (Acres)	71,800	88,200	100,200

Population at Risk. The population at risk of flooding from a 1% ACE flood event is 94,600 for the without project condition (Alternative SB-1). A remaining population of 38,200 and 6,600 are at risk of flooding from Alternative SB-7 and SB-8, respectively. Of special concern is the population over the age of 65 living within the study area since those individuals have been shown to be at higher risk of life loss in flood events. The community of Gridley has above average representation of individuals age 65 or older.

Critical Infrastructure. A significant amount of critical infrastructure is located within the Sutter study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are facilities for fire stations, police stations, hospitals, senior living facilities, and prisons. The benefits of Alternative SB-7 are primarily centered around Yuba City and still at risk are 11 of the critical infrastructure in the communities of Biggs, Gridley and Live Oak.

Evacuation Routes. The primary urban centers in the region are Yuba City, Biggs, Gridley, and Live Oak. These communities are all located on or near California State Route 99, which runs north-south through the region. Each community is also relatively close to California State Route 20, a major east-west roadway, which could also be used in an evacuation. Highway 20 takes a generally straight east-west path across the Sacramento River and the Sutter Bypass on its way to Yuba City. The route crosses Highway-99 west of central Yuba City, and runs east through the northern Yuba City to the Feather River, which it crosses on the 10th Street Bridge into Marysville. The Sutter County Evacuation and Mass Shelter/Care Plan identifies Highway 20, 99 and 113 as the primary evacuation routes in the region. These routes are subject to change since these routes are event-specific and official routes are established by the County Sheriff's office during an emergency. The Butte County Office of Emergency Management does not have published evacuation routes at this time, but anticipates Highway 99, 162 and Colusa Highway could be used as conditions allow. During the 1997 event, seven different evacuation zones were established over seven days due to constantly changing conditions and levee breaks[4]. The main evacuation routes used for this flood event were Highway-99 north and Highway-113 south. Highway-20 west and Highway-99 south were used intermittently since all portions of these roads were not accessible at all times during the flood.

Evacuation preparation can be made days in advance for predictably rain events. For example, a 0.2% ACE (1/500 year event) rain storm would be identified by meteorologist and residents could be given notice days in advance. As a significant rain event nears, warnings and evacuation efforts would be increased and reiterated. This would allow time for evacuation of immobile residents and other people with special evacuation needs (hospitals, rest homes, jails, elderly individuals, schools) via the established routes. However, none of the historical flooding evacuations in the region have been due to foreseen

[4] Source: Sutter County Office of Emergency Management.

weather events. Historical flood evacuations in the region have been from levee failures due to underseepage, which is characterized by its unpredictability and sudden occurrence. The result is evacuations after levees have failed and widespread flooding is in progress. The 1955 flood occurred due to a levee break in late December where no prior evacuation notice was given. In the 1997 flood, Yuba City was evacuated and during the evacuation a levee on the east side of the Feather River near Olivehurst (which was not evacuated) broke.

The residual 1% ACE (1/100 year event) resulting from Alternative SB-7 impacts every major urban center and nearly every primary evacuation route in the region. The floodplain is due to potential levee failure upstream of Sunset Weir. All routes out of Biggs, Gridley and Live Oak are impacted by the residual floodplain. The only egress from Yuba City would be Highway 20 east into Marysville, which is a community surrounded by a ring levee. Additionally, heading eastbound entails driving over a four lane bridge that is not expected to adequately handle the additional traffic flow, and may create a bottle neck limiting evacuation.

Wise Use of Floodplains. A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this analysis is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without and With-Project Comparison. Corps assessment of beneficial and adverse effects are based on comparison of with-project alternatives to the future without-project alternative condition expected to prevail. The social effects of the alternatives have both direct and indirect effects. Direct effects result immediately from construction of the projects, whereas indirect effects result from the effects of the project on the existing social landscape in the study area. A first step is describing or characterizing the alternatives in terms of descriptors such as magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 17 provides a description of the effects of each alternative, including the no action.

Table 17. Characterization of Alternative Effects

	SB-1	SB-7	SB-8
1. ALTERNATIVE DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. OTHER SOCIAL EFFECTS			
Summary	Continued flood risk and consequences in the Sutter Basin including the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Significant life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs.	Flood Warning Emergency Evacuation Plan (FWEEP) mitigation is problematic for types of levee failures and limited evacuation routes. Life safety residual risk to the communities of Yuba City, Live Oak, Gridley, and Biggs are significantly reduced.
Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave communities unable to cope with the recovery from a flood hazard.	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at risk of flood hazards and may be unable to cope and recover.	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.

6. REGIONAL ECONOMIC DEVELOPMENT

Purpose and Methodology. The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while National Economic Development and Environmental Quality accounts are required, display of the Regional Economic Development effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the State of Louisiana. Besides the devastating damage to homes (which are often captures by the NED account), hundreds of thousands lost their jobs, property values fell, and tourism and tax revenues declined significantly and moved to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to locate in the newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. As such, they may not influence the net value of the nation's output of goods and services and should be excluded from NED computations.

RED Concepts. The RED account has been given less emphasis in the Corps' past or current guidance. Perhaps the most extensive statement on RED appeared in the Principles and Guidance earlier version, the Principles and Standards:

> *"Through its effects—both beneficial and adverse—on a region's income, employment, population, economic base, environment, social development and other factors, a plan may exert a significant influence on the course and direction of regional development. The regional development account embraces several types of beneficial effects, such as (a) increased regional income, (b) increased regional employment, (c) population distribution, (d) diversification of regional economic base, and (e) enhancement of environmental conditions of special regional concern."*

Econometric analysis allows for the evaluation of the full range of economic impacts related to specific economic activities (construction and procurement) by calculating the direct, indirect and induced effects of the activities in the specific geographical designation.

- Direct Effects: consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect Effects: define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.

- Induce Effects: measure the consumption expenditures of direct and indirect sector employees.

Input-output(I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption. Additionally, the I/O model can be used to quantify the multiplier effect. In economics, the multiplier effects refers to the idea that an increase in spending can lead to even greater increase in income and consumption, as monies circulate or multiply through the economy.

Flood Risk Management RED Considerations. There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 18.

Table 18. Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damage property, repairs, etc and potential increase in property values.

Regional Economic System Results. A variety of software programs are available to determine the RED impacts for each project. Depending on the level of effort, project purpose, precision requirements and size of the study area, application will most likely vary. The Corps of Engineers' Institute for Water Resources along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that provides estimates of regional and national job creation, retention and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measures in jobs, income, sales and gross regional product. RECONS automates calculations and generates estimates of economic measures associated with USACE's annual civil work program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database and RECONS matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. RECONS will be used as a means to

document the performance of direct investment spending of the USACE, as it allows users to evaluate project and program expenditures associated with the annual expenditure.

The economic impacts presented below show the Sutter study area and the State of California's inter-related economic impacts resulting from an infusion of flood reduction construction funds. For this analysis, the study area and the State of California were both used as the geographic designation to assess the overall economic impacts of the construction funds. This places a frame around the economic impacts where the activity is internalized. Leakages (payments made to imports or value added sectors, which do not in turn re-spend the dollars within the area) are not included in the total impacts.

Table 19 serves to demonstrate the complex nature of the Yuba City Metropolitan Statistical Area (MSA) in 2008. There are approximately 64,844 persons employed in the MSA of Yuba City, California providing an output to the national of $8,214,000,000 annually.

Table 19. Regional Profile
Yuba City Metropolitan Statistical Area, California
(Values in Millions, 2012 Dollars)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$190	$62	$94	3,507
Administrative and Waste Management Services	$179	$80	$109	2,682
Agriculture, Forestry, Fishing and Hunting	$698	$176	$326	6,260
Arts, Entertainment, and Recreation	$49	$14	$21	753
Construction	$539	$222	$243	3,686
Education	$262	$222	$250	4,491
Finance, Insurance, Real Estate, Rental and Leasing	$503	$111	$350	3,523
Government	$1,203	$859	$1,077	11,767
Health Care and Social Assistance	$594	$335	$385	6,389
Imputed Rents	$678	$89	$431	3,901
Information	$342	$37	$75	603
Management of Companies and Enterprises	$37	$14	$19	233
Manufacturing	$1,115	$152	$233	2,698
Mining	$243	$56	$147	555
Professional, Scientific, and Technical Services	$258	$118	$144	2,421
Retail Trade	$574	$240	$390	7,058
Transportation and Warehousing	$268	$101	$141	2,476
Utilities	$166	$28	$77	201
Wholesale Trade	$315	$120	$206	1,639
Total	**$8,214**	**$3,036**	**$4,718**	**64,844**

The total remaining costs for the project is estimated at 431,000,000 and 751,000,000 for alternative SB-7 and SB-8, respectively. In conducting the regional economic development analysis, the costs needed to be adjusted for two items: (1) interest during construction and (2) purchase of land. Interest during construction is the interest that is paid back to the federal treasury to cover the bond payments made in the construction of the project. These funds are not expended within the region and therefore are not included

within the regional analysis. Similarly, the purchase of land, not counting administrative costs, are considered as transfer payments from one party to another and not considered in the analysis.

Table 20 is based on the average annual regional expenditures that are expected over the remaining construction period. The construction schedule for alternative SB-7 is five years and seven years for alternative SB-8. Over that period of construction, a total of 384,062,000 (SB-7) and 686,692,000 (SB-8) is anticipated to be spent in the Sutter Basin study area in order to complete construction effort and place the project beneficial status. The average construction expenditure is the anticipated amount divided by the years of constructions, 76,812,000 (SB-7) and 98,098,000 (SB-8).

Table 20. Input Assumptions
Yuba City Metropolitan Statistical Area, California
(Values in Thousands, 2012 Dollars)

Category	Spending	Spending Ammount		Local Percentage Capture		
		SB-7	SB-8	Local	State	National
Aggregate Materials	10%	38,406	68,669	94%	96%	99%
Other Materials	1%	3,841	6,867	100%	100%	100%
Equipment	35%	134,422	240,342	90%	99%	100%
Construction Labor	54%	207,393	370,814	100%	100%	100%
Total	100%	384,062	686,692	-	-	-

Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment. Both account for 89% of the total project expenditures. Local capture rates are computed with RECONS to show where the output from expenditures are realized. As indicated in Table 20, all of the construction labor is expected to occur within the MSA, and 90% of the equipment is expected to be provided from within the study area, and 99% from within the State of California.

Table 21 summarizes the expected economic impacts in terms of monetary output, number of jobs, labor income and gross regional product. USACE is planning on expending approximately $77,000,000 for SB-7 or $98,000,000 for SB-8 on the project. Of this total project expenditure, approximately $74,000,000 for SB-7 or $94,000,000 for SB-8 will be captured within the regional impact area. The rest will be leaked out to the State of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and gross regional product as summarized in Table 22-24.

Of significant note to the study area is the creation of jobs. Currently, the unemployment rate in the study area (8.4% in Gridley, 9.3% in Yuba City and 14.7% in Biggs) is higher than state (6.5%) and national (5.6%) averages, and the number of jobs gained within the region demonstrates the multiplier effect of this infusion of construction funds for this project.

Table 21. Summary of Economic Impacts
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Total Spending		Alternative SB-7			Alternative SB-8		
		Regional	State	National	Regional	State	National
		$384,062,000	$384,062,000	$384,062,000	$686,692,000	$686,692,000	$686,692,000
Direct Impact	Output	$73,713,365	$76,225,904	$76,697,970	$94,141,009	$97,349,830	$97,952,716
	Job	5,344	5,386	5,397	9,556	9,630	9,649
	Labor Income	$51,467,519	$52,135,157	$52,306,415	$65,730,335	$66,582,991	$66,801,709
	GRP	$59,477,394	$60,876,748	$61,141,251	$75,959,928	$77,747,074	$78,084,878
Total Impact	Output	$125,962,039	$153,322,937	$202,554,134	$160,868,975	$195,812,199	$258,686,476
	Job	7,324	8,099	9,469	13,095	14,480	16,930
	Labor Income	$68,495,021	$78,658,749	$94,442,866	$87,476,544	$100,456,871	$120,615,125
	GRP	$90,623,778	$106,865,898	$134,174,527	$115,737,681	$136,480,861	$171,357,330

Table 22. Economic Impacts—Regional Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$379,606	$2	$156,322	$291,353	$678,724	$4	$279,499	$520,931
	Transport by rail	$575,297	$2	$176,467	$305,113	$1,028,615	$3	$315,517	$545,534
	Transport by water	$87,856	$0	$35,097	$38,076	$157,084	$0	$62,753	$68,080
	Transport by truck	$12,769,011	$90	$6,502,420	$7,554,866	$22,830,630	$162	$11,626,143	$13,507,886
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$121,055,375	$398	$30,157,286	$66,534,853	$216,443,588	$711	$53,920,375	$118,962,436
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$368,566,825	$5,344	$257,337,593	$297,386,971	$658,987,065	$9,556	$460,112,343	$531,719,499
Secondary Effects		$261,243,369	$1,980	$85,137,512	$155,731,920	$467,095,760	$3,539	$152,223,464	$278,444,272
Total Effects		$629,810,195	$7,324	$342,475,105	$453,118,892	$1,126,082,826	$13,095	$612,335,807	$810,163,770

Table 23. Economic Impacts—State Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$564,590	$3	$237,707	$435,390	$1,009,471	$6	$425,014	$778,464
	Transport by rail	$841,594	$3	$261,098	$448,343	$1,504,746	$5	$466,837	$801,624
	Transport by water	$292,567	$1	$116,876	$128,879	$523,101	$1	$208,971	$230,432
	Transport by truck	$12,769,011	$90	$6,502,420	$7,554,866	$22,830,630	$162	$11,626,143	$13,507,886
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$132,962,079	$437	$33,247,683	$73,153,551	$237,732,438	$781	$59,445,917	$130,796,481
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$381,129,521	$5,386	$260,675,786	$304,383,738	$681,448,811	$9,630	$466,080,937	$544,229,520
Secondary Effects		$385,485,165	$2,713	$132,617,959	$229,945,753	$689,236,579	$4,850	$237,117,163	$411,136,507
Total Effects		$766,614,686	$8,099	$393,293,745	$534,329,491	$1,370,685,390	$14,480	$703,198,099	$955,366,027

Table 24. Economic Impacts—National Level
Yuba City Metropolitan Statistical Area, California
(2012 Dollars)

Industry Sector		Alternative SB-7				Alternative SB-8			
		Sales	Jobs	Labor Income	GRP	Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$21,697,457	$123	$11,326,872	$13,143,722	$38,794,440	$219	$20,252,126	$23,500,604
	Wholesale trade businesses	$572,245	$3	$241,075	$441,350	$1,023,158	$6	$431,036	$789,122
	Transport by rail	$1,094,648	$3	$342,266	$585,701	$1,957,200	$6	$611,962	$1,047,216
	Transport by water	$423,734	$1	$169,276	$188,624	$757,625	$2	$302,660	$337,254
	Transport by truck	$13,474,219	$96	$6,861,536	$7,972,107	$24,091,523	$172	$12,268,233	$14,253,901
	Construction of other new nonresidential structures	$4,608,744	$30	$1,589,650	$2,125,508	$8,240,304	$54	$2,842,249	$3,800,348
	Commercial & industrial machinery & equipment rental/leasing	$134,225,323	$441	$33,607,922	$73,855,763	$239,991,084	$789	$60,090,014	$132,052,017
	Labor	$207,393,480	$4,699	$207,393,480	$207,393,480	$370,813,680	$8,402	$370,813,680	$370,813,680
Total Direct Effects		$383,489,851	$5,397	$261,532,077	$305,706,255	$685,669,014	$9,649	$467,611,961	$546,594,143
Secondary Effects		$629,280,820	$4,072	$210,682,253	$365,166,380	$1,125,136,318	$7,281	$376,693,912	$652,907,165
Total Effects		$1,012,770,671	$9,469	$472,214,329	$670,872,635	$1,810,805,332	$16,930	$844,305,873	$1,199,501,308

7. ECONOMIC SUMMARY

A summary table of the cost benefit analysis, other social effects assessment and the regional economic development benefits is detailed in Table 25.

Table 25. Summary of Analyses

	SB-1	SB-7	SB-8
1. PLAN DESCRIPTION			
	Alternative SB-1: The No Action provides no physical project constructed by the Federal Government.	Alternative SB-7: The plan is a Feather River fix-in-place levee alternative from Sunset Weir to Laurel Avenue.	Alternative SB-8: The plan is a Feather River fix-in-place levee alternative from Thermalito to Laurel Avenue.
2. SUMMARY OF IMPACT ANALYSES			
A. National Economic Development (NED)			
1. Annual Damages	$ 112,046,000	$ 48,146,000	$ 41,476,000
2. Annual Benefits	$ -	$ 63,900,000	$ 70,570,000
3. Total Project Costs	$ -	$ 432,000,000	$ 748,110,000
a. IDC	$ -	$ 44,000,000	$ 107,000,000
b. O&M	$ -	$ 280,000	$ 450,000
c. Annual Cost	$ -	$ 21,000,000	$ 38,000,000
d. Construction Period		5 years	7 years
4. Annual Net Benefits	$ -	$ 43,000,000	$ 33,000,000
5. Benefit-to-Cost Ratio	-	3.0	1.9
B. Other Social Effects (OSE)			
Population at Risk	Approximately **96,600** individuals are within the 1% ACE floodplain.	**38,200** people remain in the 1% ACE floodplain. (60% of population is removed from the 1% ACE residual floodplain.)	**6,600** people remain in the 1% ACE floodplain. (93% of population is removed from the 1% ACE residual floodplain)
Loss of Life	Potential loss of lives: **Day-388, Night-489**	Potential loss of lives: **Day-157, Night-197**	Potential loss of lives: **Day-27, Night-34**
Critical Infrastructure	**28** structure deemed as critical from a national perspective are at risk from floods.	**11** structures remain at risk from floods.	**1** structure is at risk from floods.
Evacuation Routes	In the event of a flood, no evacuation route is available out of the basin.	Offers **one** problematic route for evacuation during a flood event. A flood warning and evacuation plan would not be as effective and limited.	**5** evacuation routes are available in the event of a flood. A flood warning and evacuation plan would have more robustness and redundancy.
Wise Use of Floodplains	Currently, 71,800 acres of land are potentially available for future development.	88,200 acres would be potentially available for future development.	100,200 acres of land would be potentially available for future development.
Social Vulnerability	The social vulnerability index score (SoVi) indicates the study area to be medium to high vulnerability. The No Action alternative may leave	Majority of the community of Yuba City is afforded flood risk reduction, however the communities of Live Oak, Gridley, and Biggs remain at	The four existing communities are provided flood risk reduction, and social vulnerability is minimized due to a decrease in the probability of

	SB-1	SB-7	SB-8
	communities unable to cope with the recovery from a flood hazard.	risk of flood hazards and may be unable to cope and recover.	flood hazards occurring.
Residual Risk and Consequences	Residual Risk remains high throughout the study area	Residual Risk for Life Safety is reduced for most of the Yuba City urban area.	Residual Risk for Life Safety is reduced in the high risk communities: Yuba City, Live Oak, Gridley and Biggs.
C. Regional Economic Development (RED)—Regional Direct Impacts			
Output	$8,214,000,000	SB-1 + $73,713,000 (5yrs)	SB-1 + $94,141,000 (7yrs)
Job	64,844	SB-1 + 5,344 (5yrs)	SB-1 + 9,556 (7yrs)
Labor Income	$3,036,000,000	SB-1 + $51,468,000 (5yrs)	SB-1 + $65,730,000 (7yrs)
Gross Regional Product	$4,718,000,000	SB-1 + $60,877,000 (5yrs)	SB-1 + $75,960,000 (7yrs)


PLATE #1
Legend
Sutter Basin Study Area
Sacramento Basin
Watershed Boundary
Lake or Reservoir
Designated Floodway
River or Stream
City
Medford
OREGON
Goose Lake
Mt. Shasta, 14,179 ft
Pit River
Shasta Lake
Redding
CALIFORNIA
NEVADA
Lake Almanor
Sacramento River
Black Butte Lake
Chico
Lake Oroville
Reno
Butte Basin
New Bullards Bar Lake
Feather River
Yuba R
Clear Lake
Indian Valley Reservoir
Yuba City
Lake Tahoe
Colusa Drain
Camp Far West Lake
Cache Cr
Folsom Lake
Lake Berryessa
American R
PACIFIC
Santa Rosa
Sacramento
OCEAN
Stockton
Miles
0
50
San Francisco
Prepared by Jim Mars, USACE

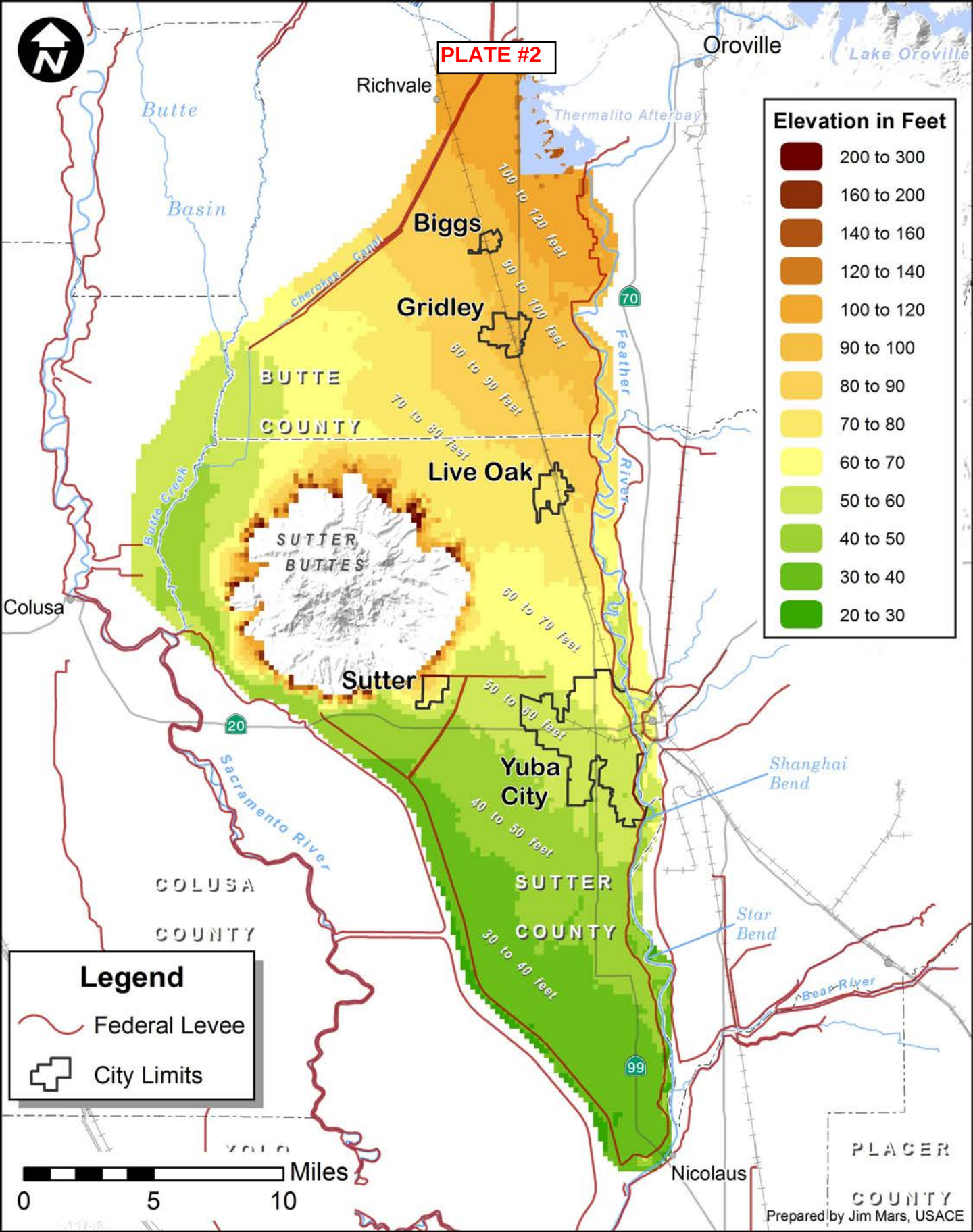


PLATE #2
Oroville
Lake Oroville
Richvale
Thermalito Afterbay
Butte
Basin
Biggs
Gridley
Cherokee Canal
100 to 120 feet
90 to 100 feet
80 to 90 feet
70 to 80 feet
60 to 70 feet
50 to 60 feet
40 to 50 feet
30 to 40 feet
BUTTE
COUNTY
Live Oak
Feather River
Butte Creek
SUTTER
BUTTES
Colusa
Sutter
Yuba
City
Shanghai
Bend
Sacramento River
COLUSA
COUNTY
SUTTER
COUNTY
Star
Bend
Bear River
Nicolaus
PLACER
COUNTY
70
20
99
Elevation in Feet
200 to 300
160 to 200
140 to 160
120 to 140
100 to 120
90 to 100
80 to 90
70 to 80
60 to 70
50 to 60
40 to 50
30 to 40
20 to 30
Legend
Federal Levee
City Limits
Miles
0
5
10
Prepared by Jim Mars, USACE

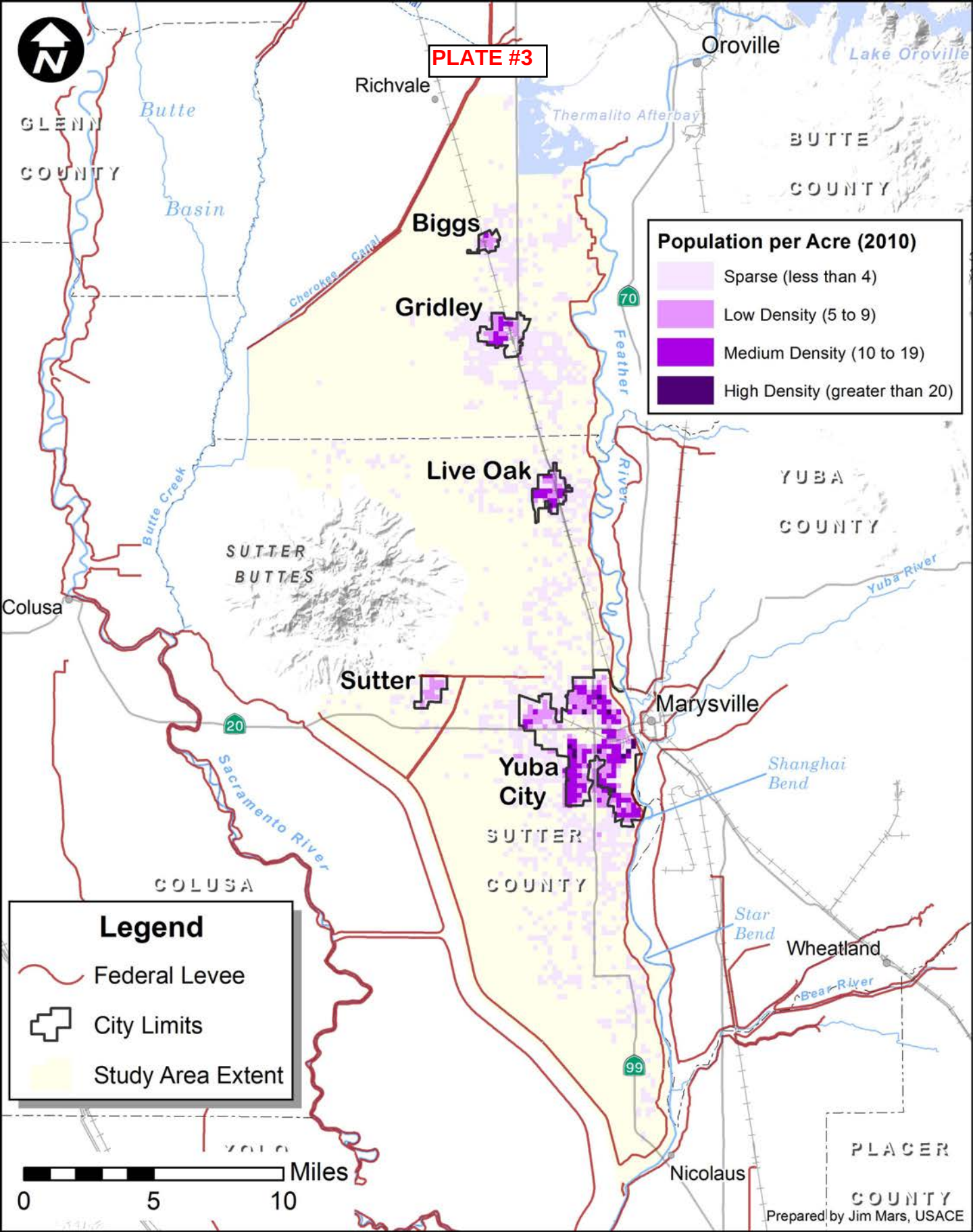


PLATE #3
Oroville
Lake Oroville
Richvale
Thermalito Afterbay
GLENN
COUNTY
Butte
Basin
BUTTE
COUNTY
Biggs
Gridley
Cherokee Canal
70
Feather River
Population per Acre (2010)
Sparse (less than 4)
Low Density (5 to 9)
Medium Density (10 to 19)
High Density (greater than 20)
Live Oak
Butte Creek
YUBA
COUNTY
SUTTER
BUTTES
Yuba River
Colusa
Sutter
Marysville
20
Yuba
City
Shanghai
Bend
Sacramento River
SUTTER
COUNTY
COLUSA
Star
Bend
Wheatland
Bear River
99
Legend
Federal Levee
City Limits
Study Area Extent
Miles
0
5
10
Nicolaus
PLACER
COUNTY
Prepared by Jim Mars, USACE